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McLaughlin et al.

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(54) **EXPANDABLE INTERVERTEBRAL IMPLANT**

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(52) **U.S. Cl.**

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See application file for complete search history.

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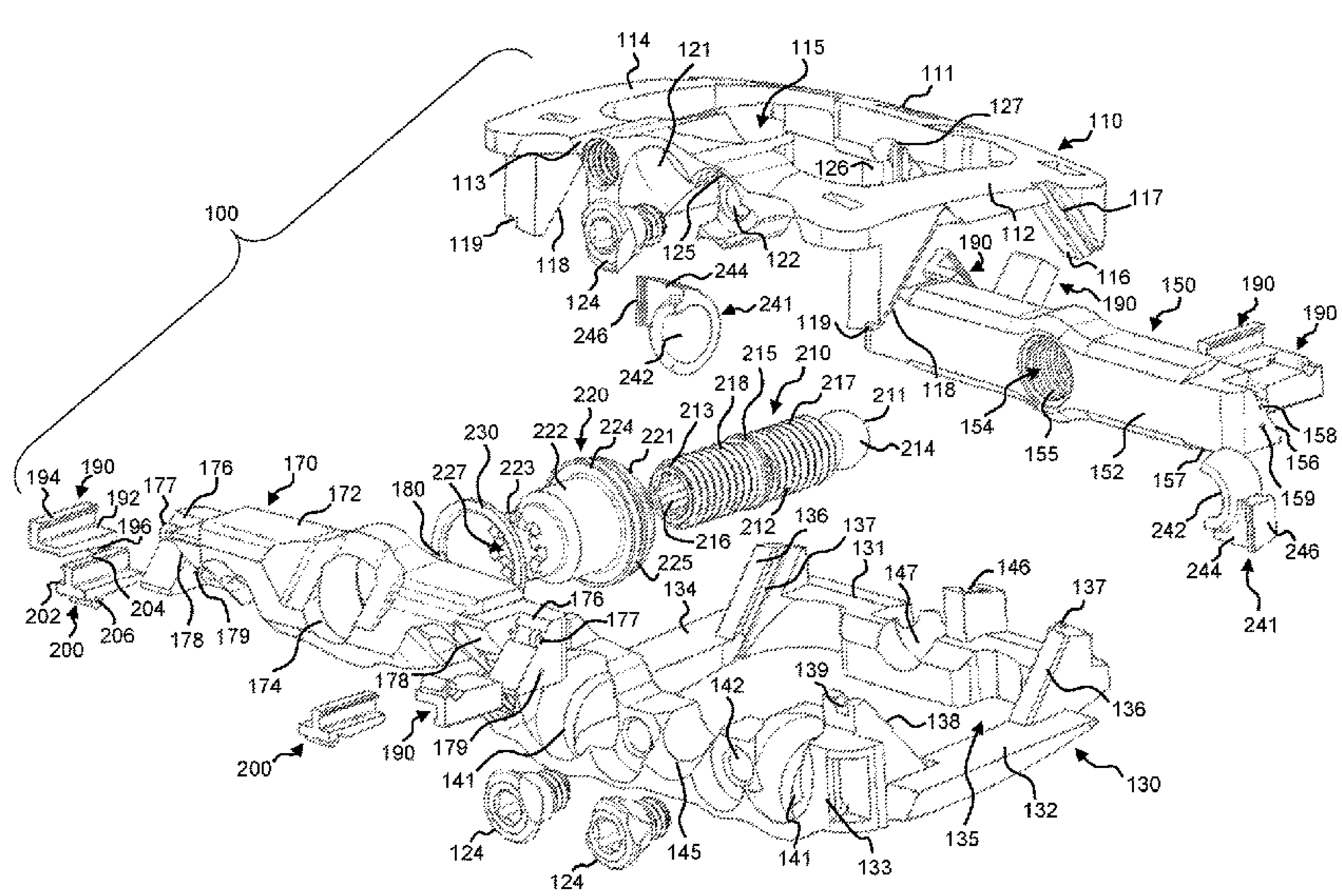
Primary Examiner — Anu Ramana

(57) **ABSTRACT**

An implant including first and second end plates, each of which defines at least one anterior ramped surface and at least one posterior ramped surface. A posterior actuator is positioned between the first and second end plates and has guiding ramp surfaces which correspond with the posterior ramped surfaces. An anterior actuator is positioned between the first and second end plates and guiding ramp surfaces which correspond with the anterior ramped surfaces. An actuator assembly extends between the posterior actuator and the anterior actuator and is configured to selectively move the posterior actuator and the anterior actuator simultaneously, move posterior actuator independently of the anterior actuator, or move the anterior actuator independently of the posterior actuator.

20 Claims, 8 Drawing Sheets



(51) **Int. Cl.**
A61F 2/30 (2006.01)
A61F 2/46 (2006.01)

(52) **U.S. Cl.**
CPC *A61F 2002/30537* (2013.01); *A61F 2002/30538* (2013.01); *A61F 2002/30556* (2013.01); *A61F 2002/30579* (2013.01); *A61F 2002/30622* (2013.01); *A61F 2002/30624* (2013.01); *A61F 2002/443* (2013.01); *A61F 2002/4625* (2013.01); *A61F 2002/4627* (2013.01)

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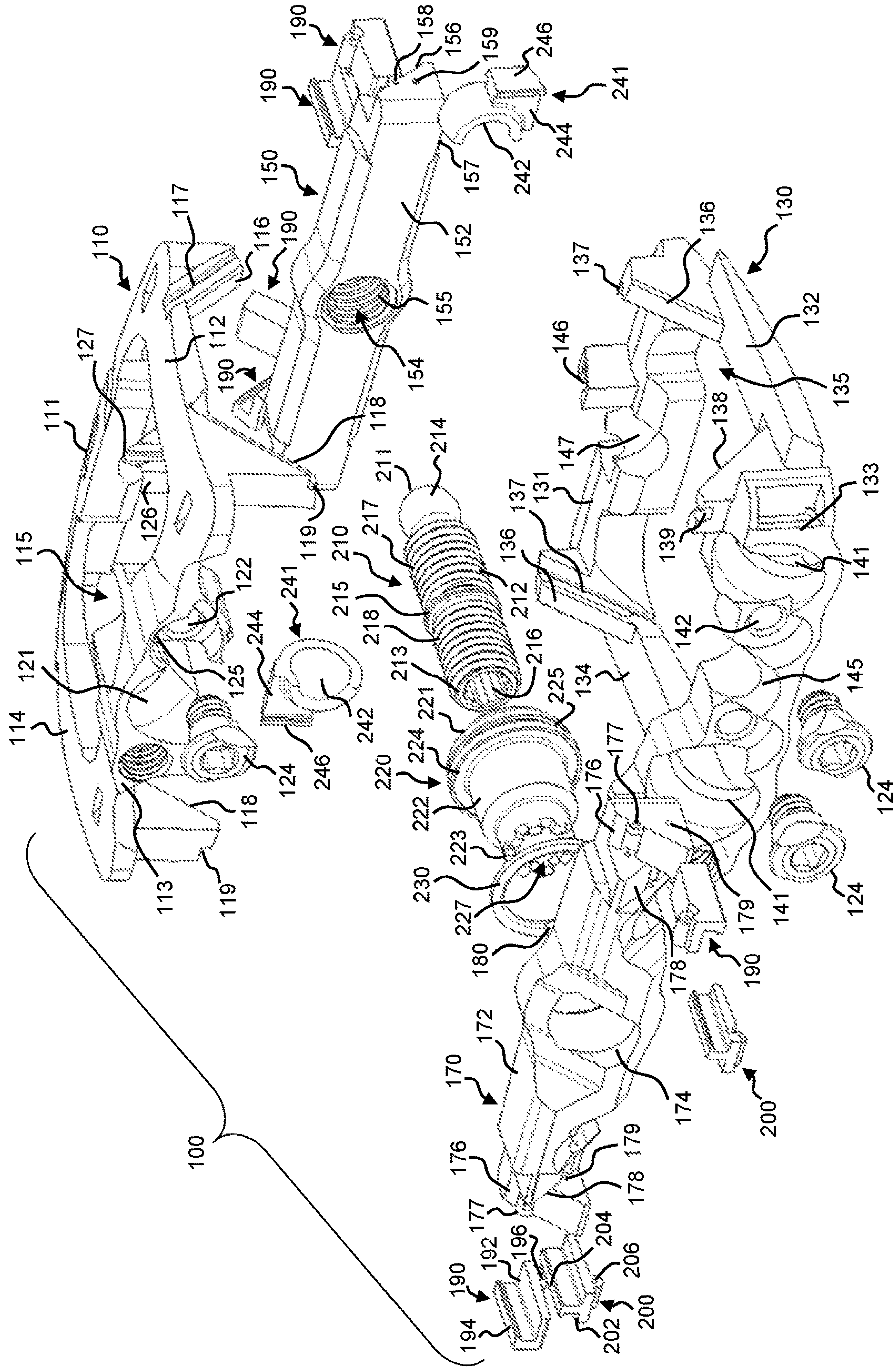
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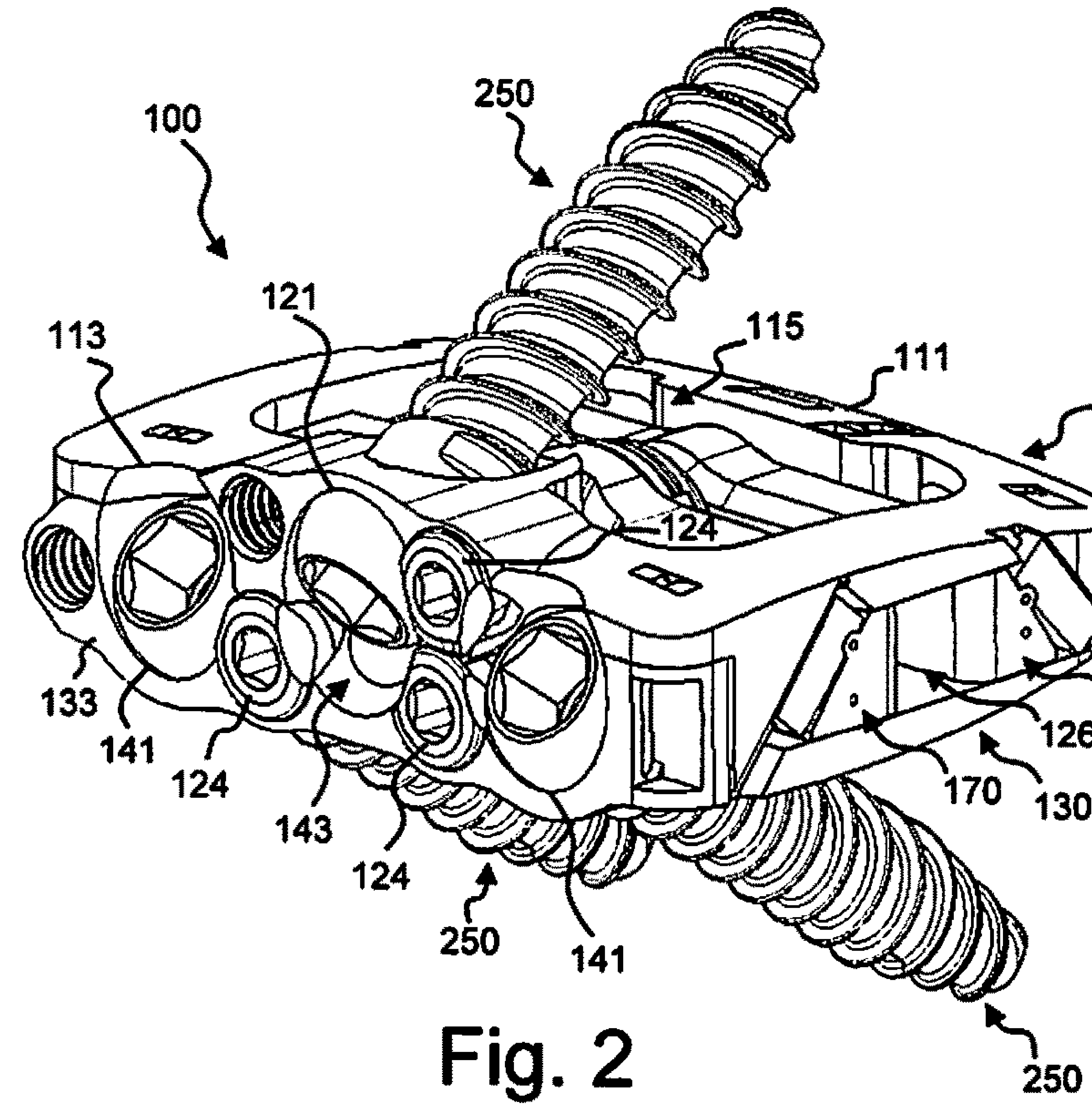
Fig. 1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250

Fig. 2

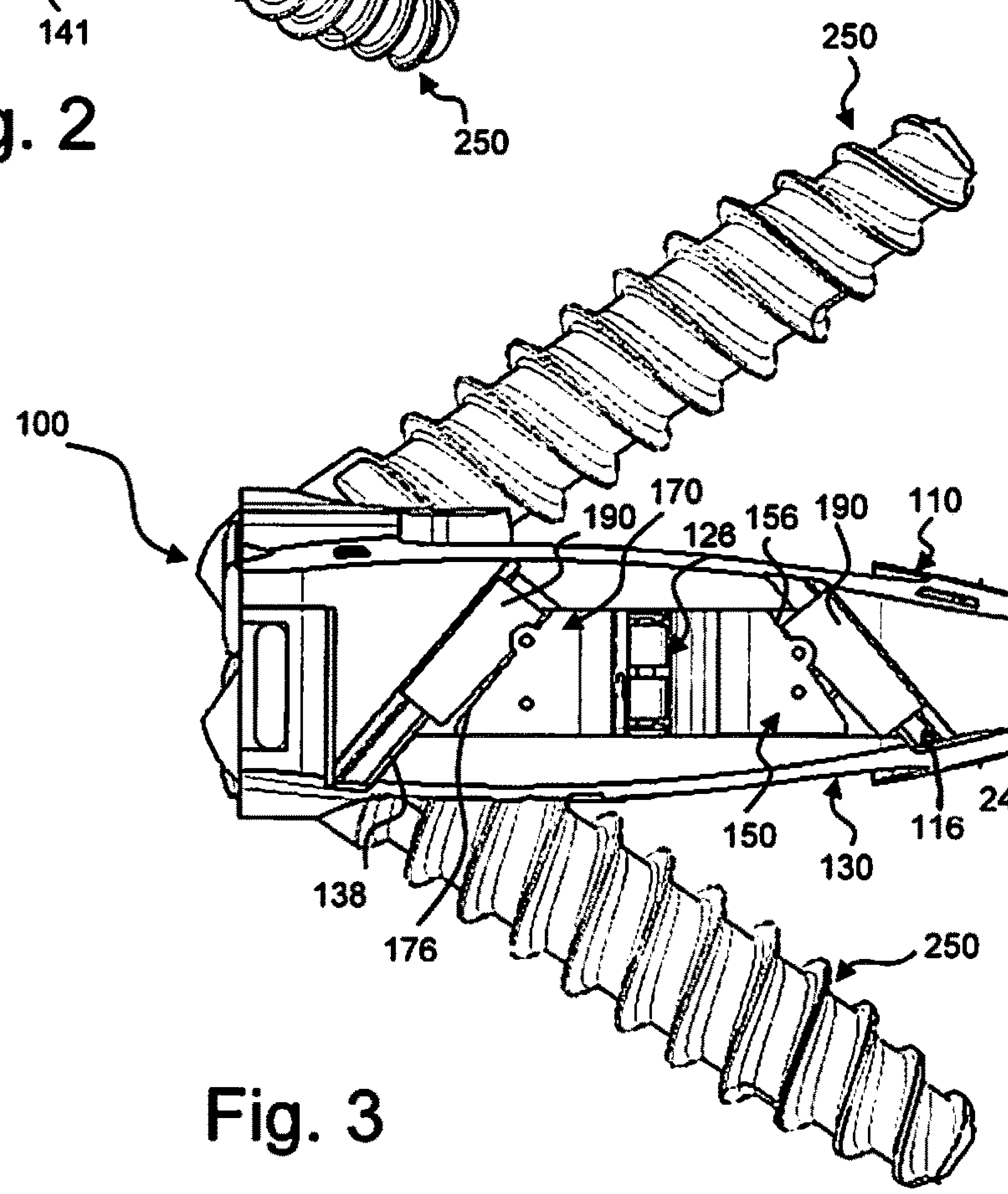
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Fig. 3

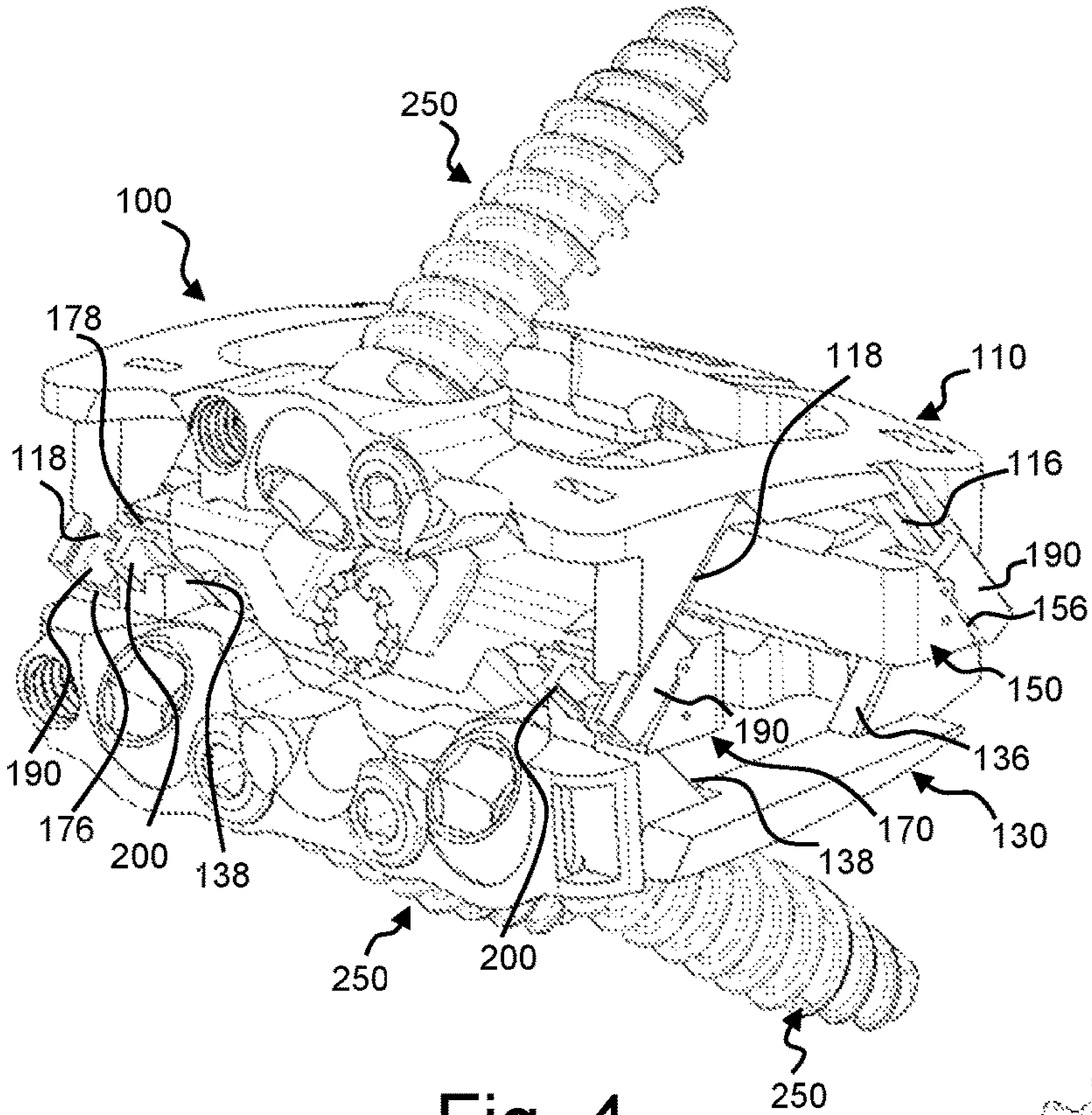
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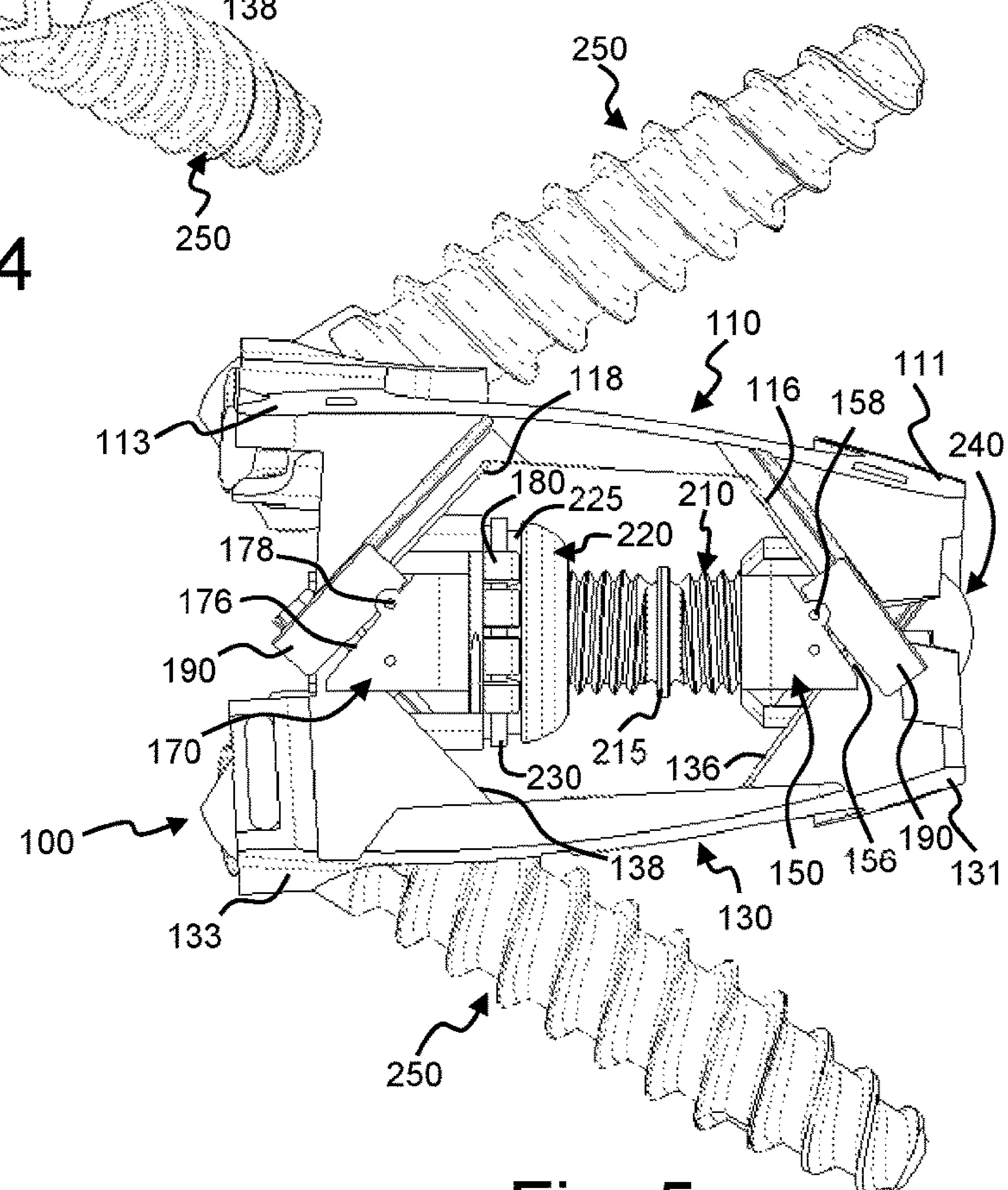
Fig. 4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131
133
250

Fig. 5

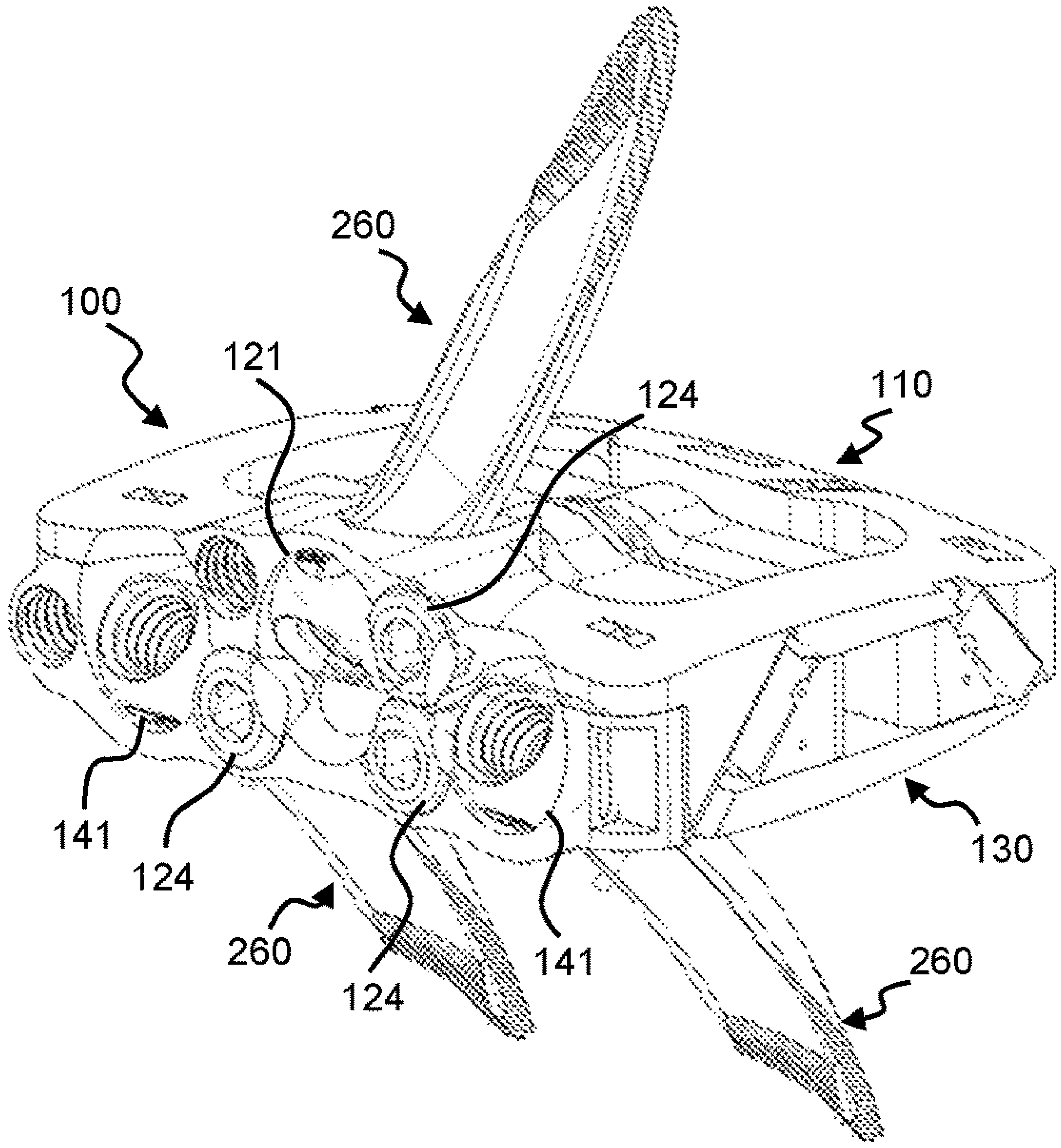
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Fig. 6

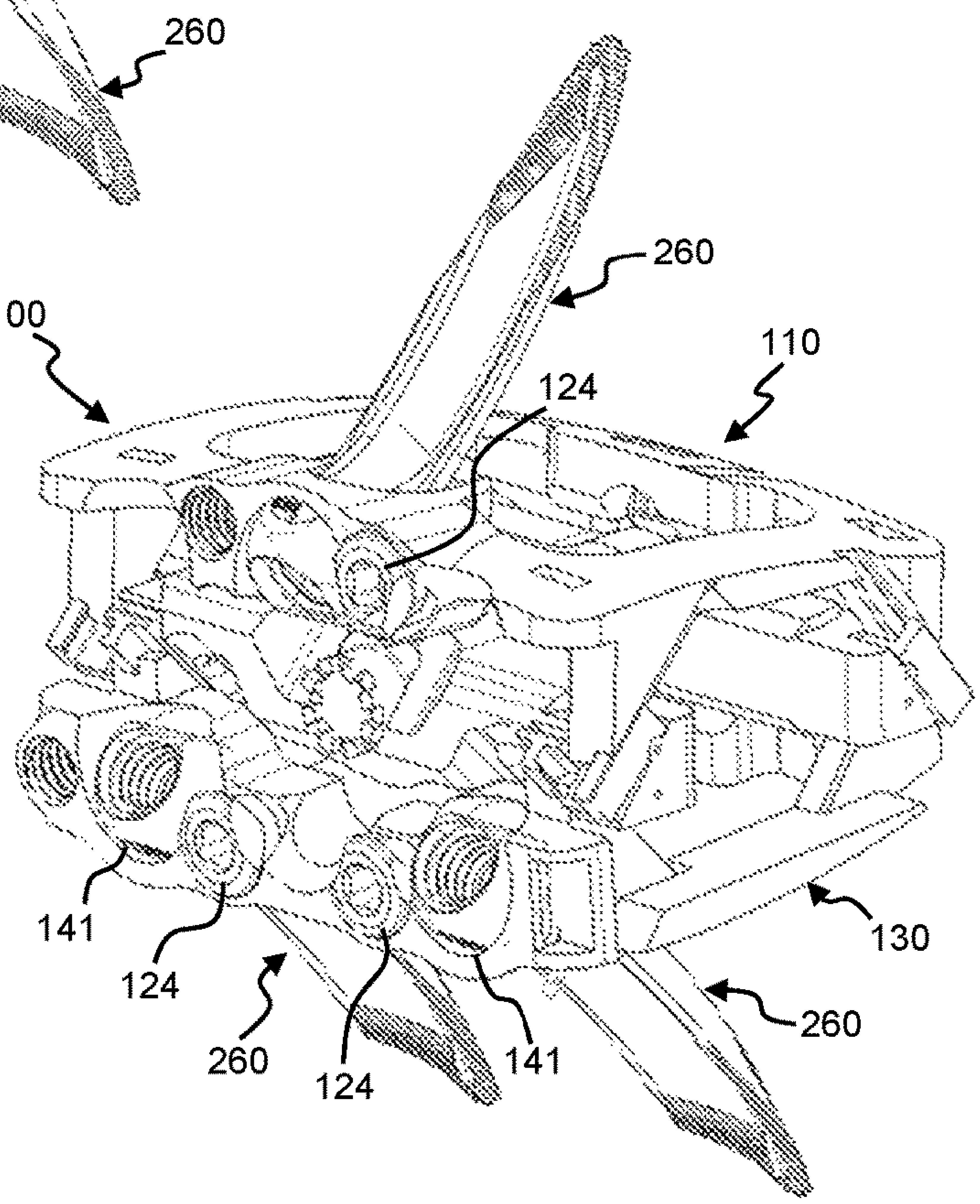
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Fig. 7

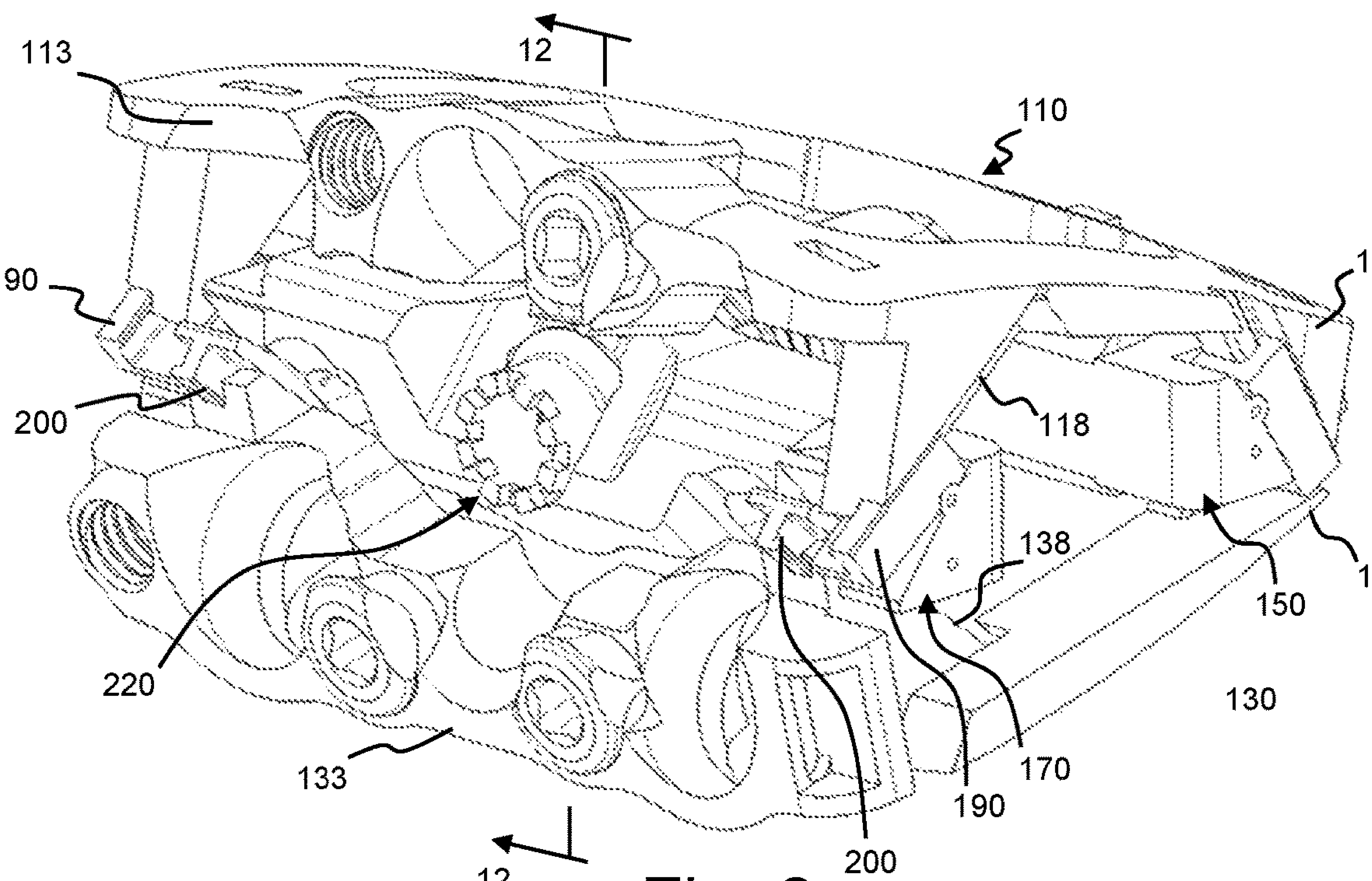
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Fig. 8

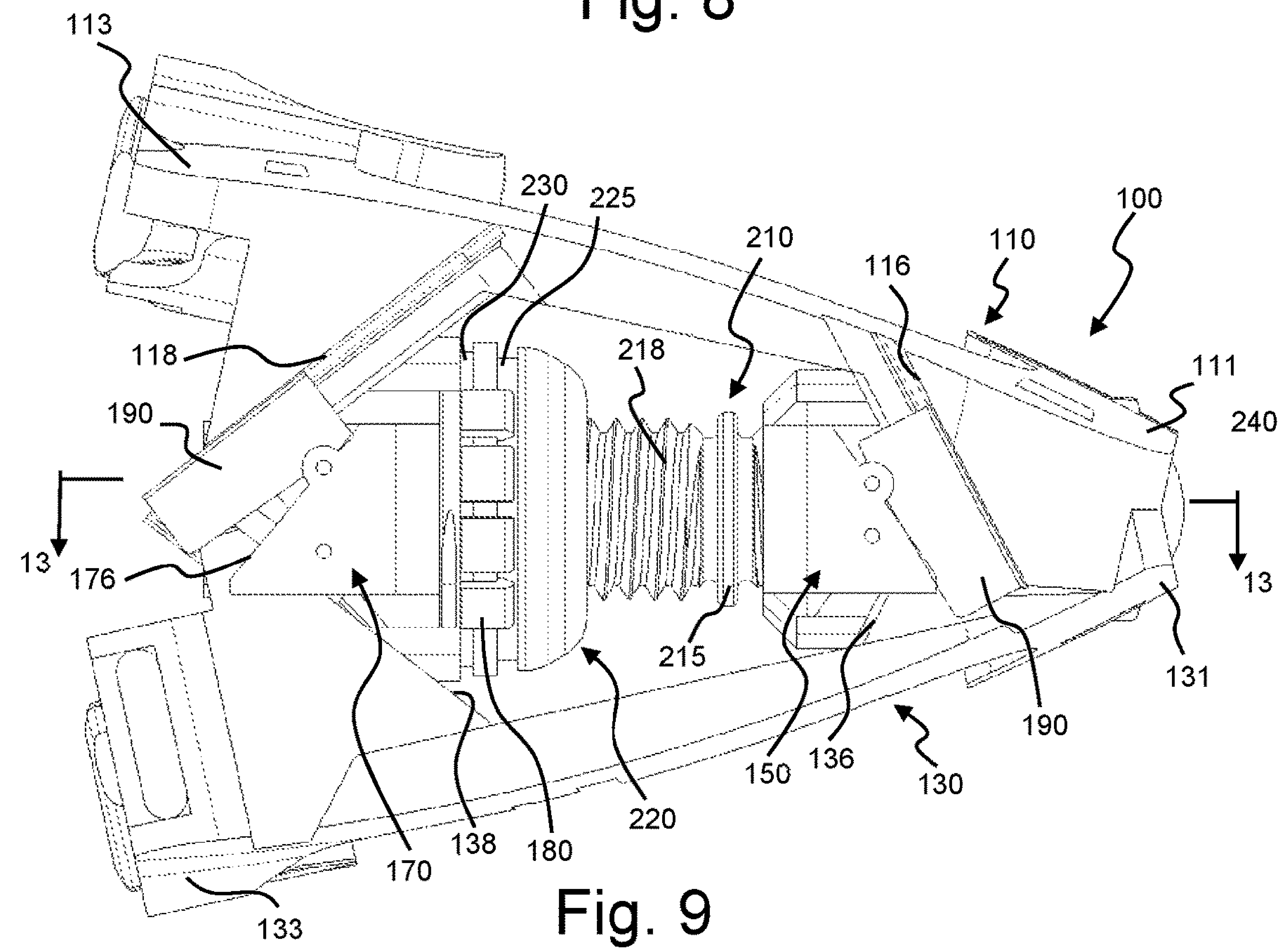
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Fig. 9

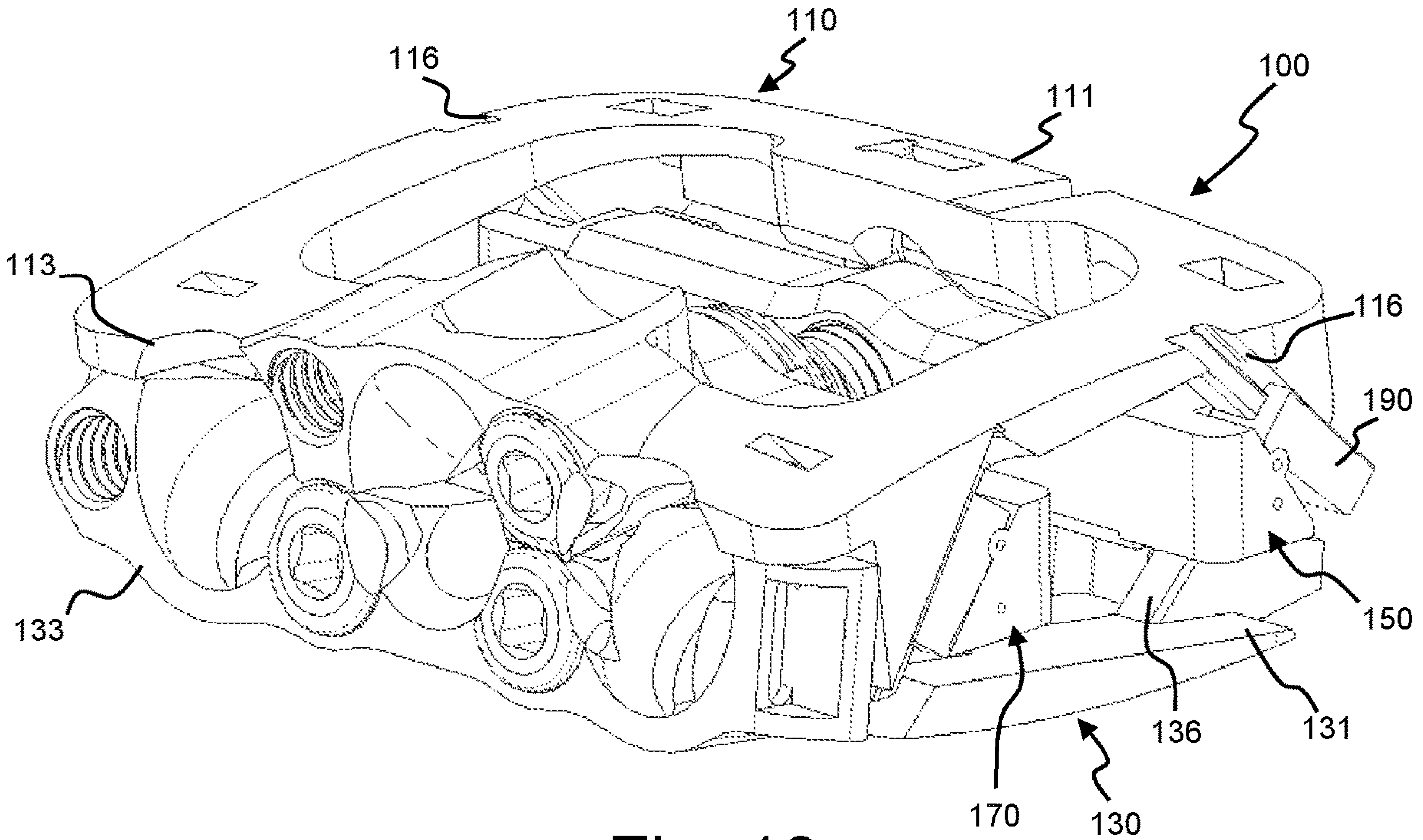
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Fig. 10

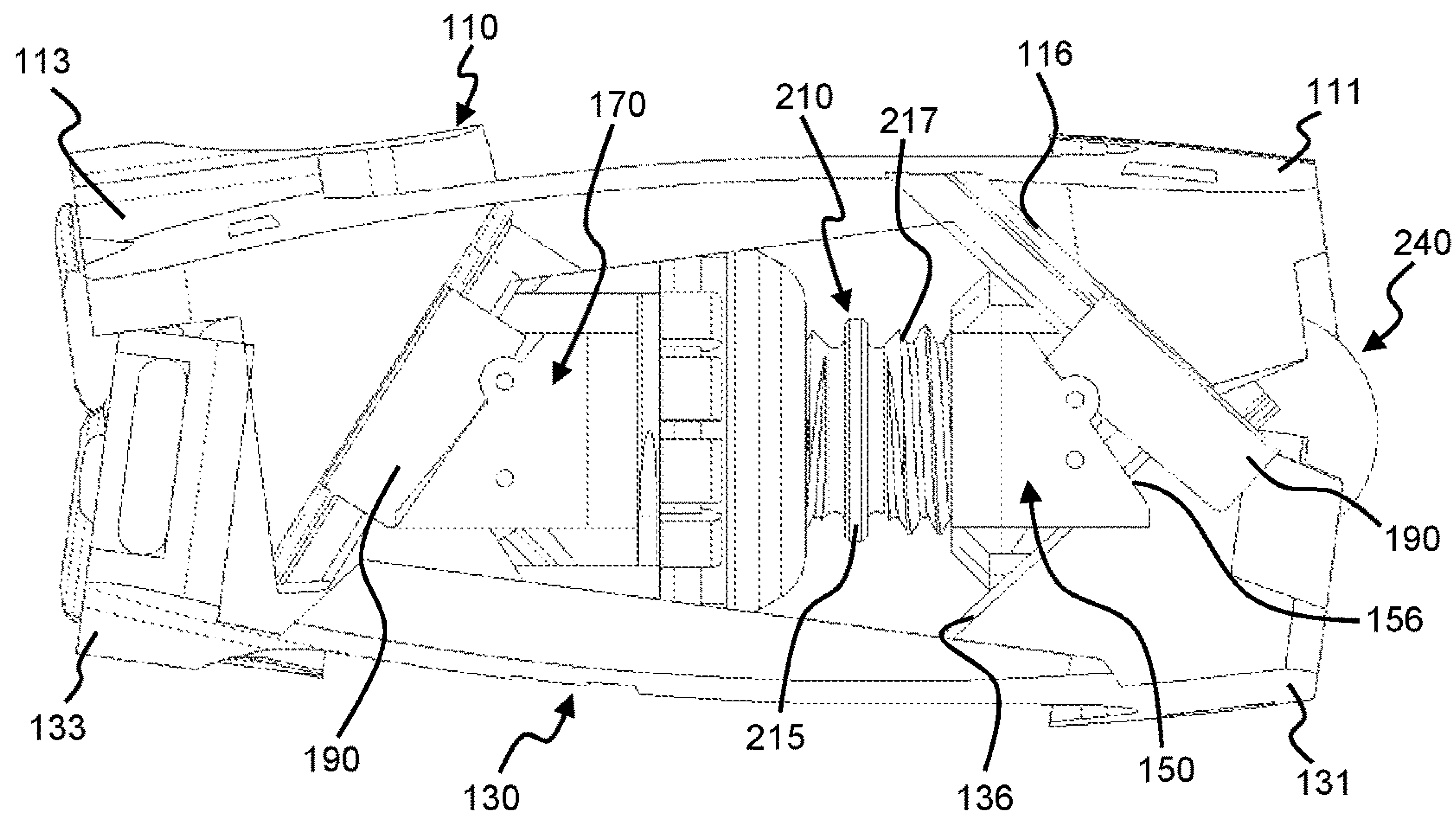
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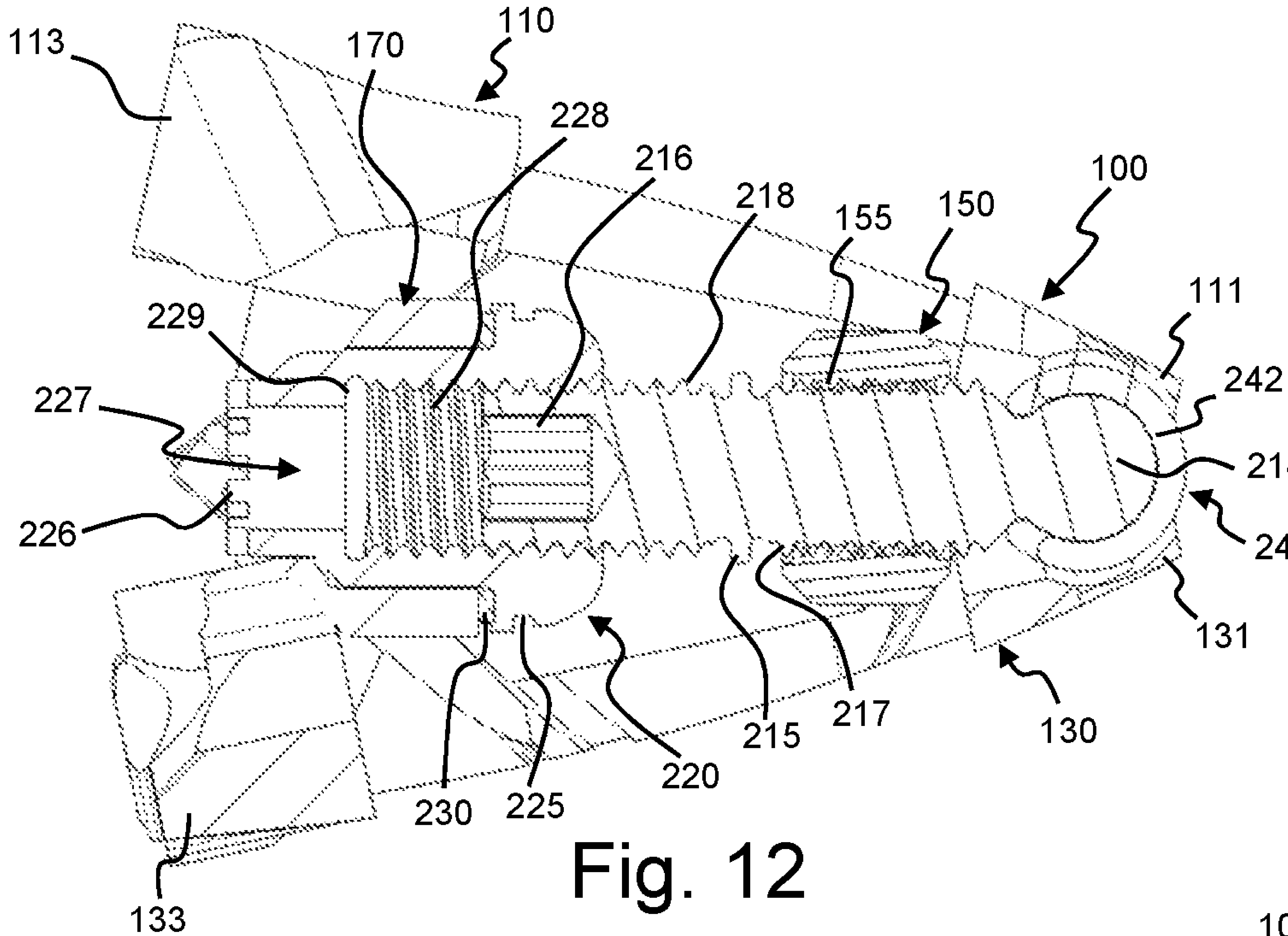
Fig. 11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133

Fig. 12

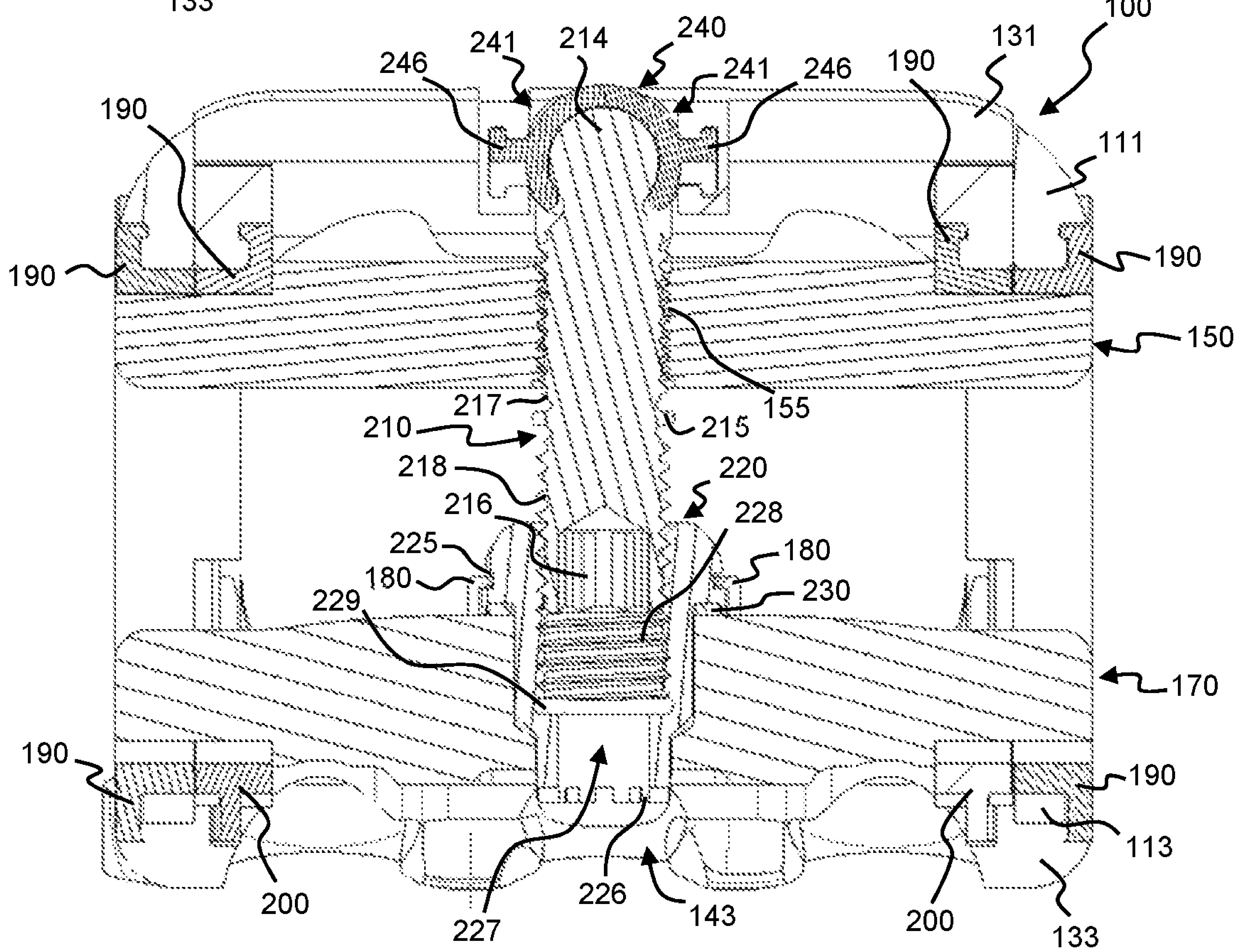
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Fig. 13

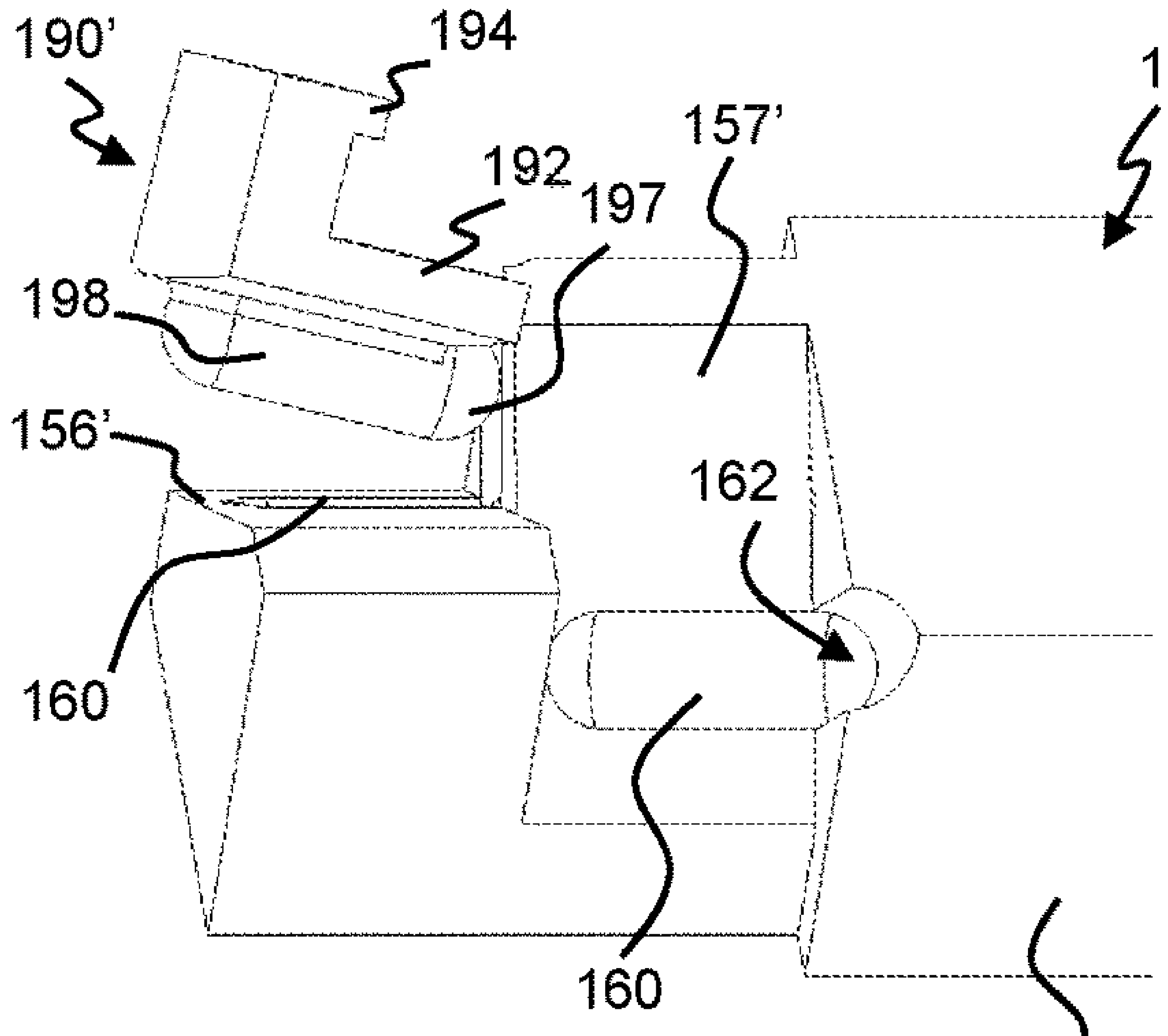

Fig. 14

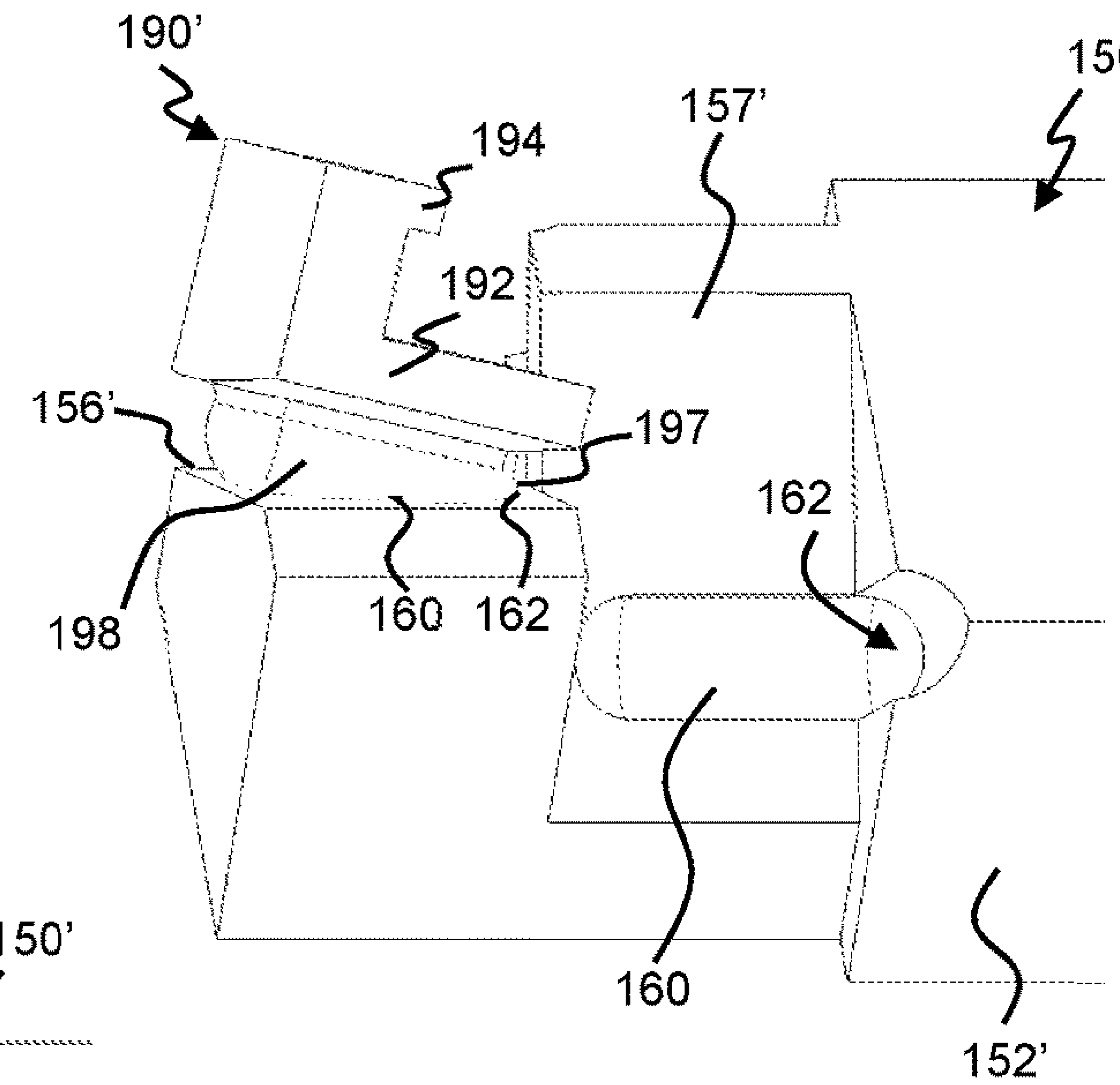

Fig. 15

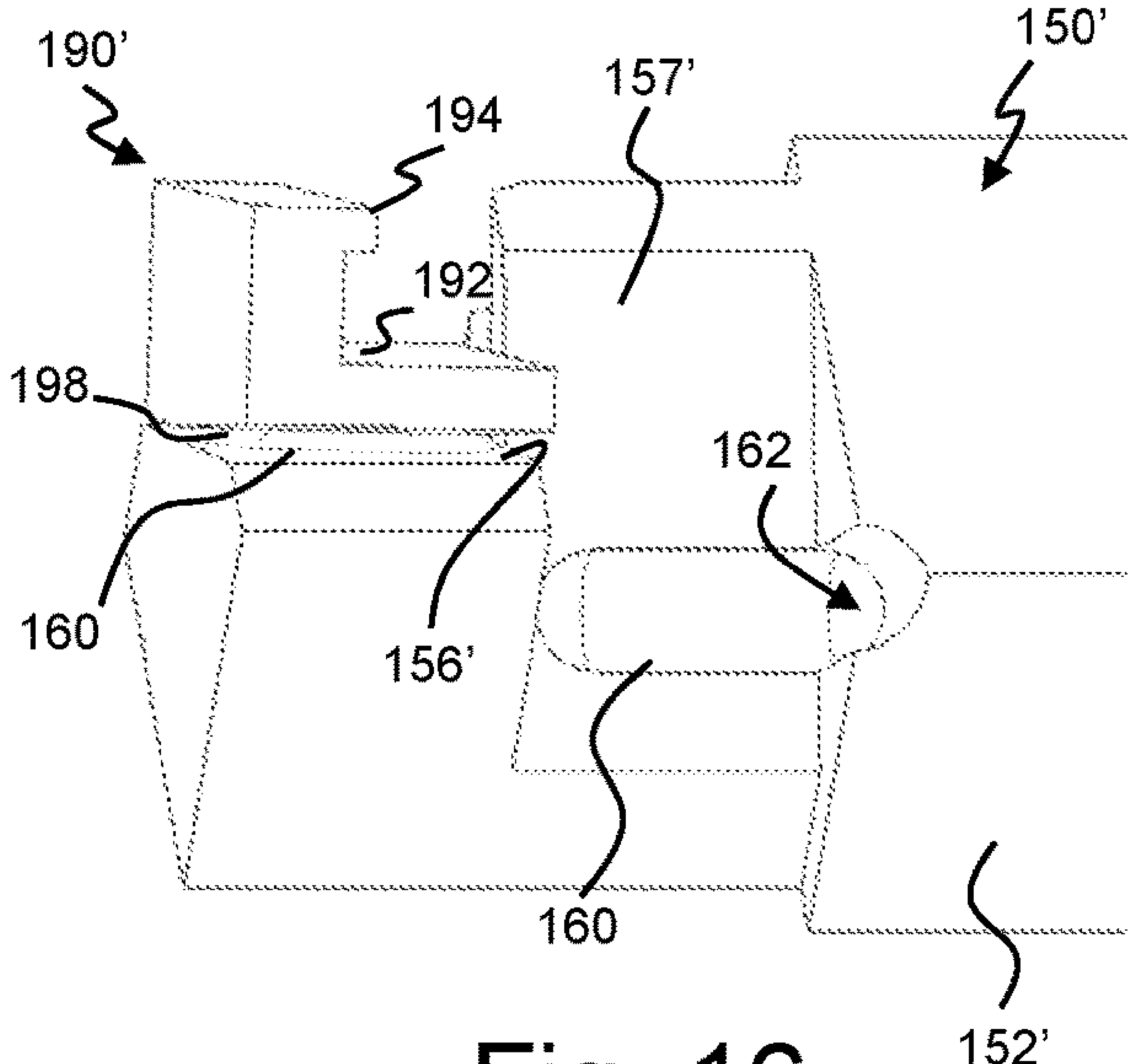

Fig. 16

EXPANDABLE INTERVERTEBRAL IMPLANT

FIELD OF THE INVENTION

This present disclosure relates to stabilizing adjacent vertebrae of the spine by inserting an intervertebral implant, and more particularly an intervertebral implant that is adjustable in height and/or angularity and associated methods.

BACKGROUND

Bones and bony structures are susceptible to a variety of weaknesses that can affect their ability to provide support and structure. Weaknesses in bony structures have numerous potential causes, including degenerative diseases, tumors, fractures, and dislocations. Advances in medicine and engineering have provided doctors with a plurality of devices and techniques for alleviating or curing these weaknesses.

In some cases, the spinal column requires additional support in order to address such weaknesses. One technique for providing support is to insert a spacer between adjacent vertebrae.

SUMMARY

To meet this and other needs, expandable implants, systems, and methods are provided. The expandable implant may be expandable and adjustable in height and/or angularity. The implant may be inserted into an intervertebral disc space at a minimized height, and then expanded axially to restore height loss in the disc space. The implant may provide distraction as well as achieving optimal height restoration. The implant may also change in lordotic angulation independently from its expansion. This independent expansion and lordotic angulation may solve some of the problems currently encountered, such as excessive impaction during insertion, visual obstruction, and imperfect matching with patient's lordosis due to discrete increments in lordotic angulation. It will be appreciated that although generally described with respect to lordotic angulation, the implant may also be configured to provide kyphotic expansion and angulation to treat kyphosis as well.

In at least one embodiment, the present disclosure provides an implant for therapeutically separating bones of a joint. The implant includes a first end plate extending between an anterior end and a posterior end. The first end plate has a bone engaging surface, at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface. A second end plate extends between an anterior end and a posterior end. The second end plate has a bone engaging surface, at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface. A posterior actuator is positioned between the first and second end plates and has a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface. A pivot member is pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a pivot member is pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface. An anterior actuator is positioned

between the first and second end plates and has a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface. A pivot member is pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a pivot member is pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface. An actuator assembly extends between the posterior actuator and the anterior actuator and is configured to selectively move the posterior actuator and the anterior actuator simultaneously, move posterior actuator independently of the anterior actuator, or move the anterior actuator independently of the posterior actuator.

In at least one embodiment, the present invention provides an implant including a first end plate extending between an anterior end and a posterior end. The first end plate defines at least one anterior ramped surface and at least one posterior ramped surface. A second end plate extends between an anterior end and a posterior end and defines at least one anterior ramped surface and at least one posterior ramped surface. A posterior actuator is positioned between the first and second end plates and has a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface. A pivot member is pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a pivot member is pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface. An anterior actuator is positioned between the first and second end plates and has a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface. A pivot member is pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a pivot member is pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface. An actuator assembly extends between the posterior actuator and the anterior actuator. The actuator assembly includes an actuator screw extending between a posterior end and an anterior end with a first external thread set proximate the posterior end and a second external thread set proximate the anterior end wherein the first and second external thread sets are oppositely handed. The posterior end of the actuator screw extends through and threadably engages a through passage in the posterior actuator. The actuator assembly further includes an actuator nut extending between a posterior end and an anterior end with a through passage extending from the posterior end to the anterior end and defining an internal thread within the through passage. The internal thread is threadably engaged with the second set of external threads. The actuator nut extends through the anterior actuator such that the actuator nut is axially fixed relative to the anterior actuator but rotatable relative thereto. Rotation of the actuator screw while the actuator nut does not rotate causes the posterior actuator and the anterior actuator to move simultaneously, rotation of the actuator screw and the actuator nut together causes the posterior actuator to move independently of the anterior actuator, and rotation of the actuator nut while the actuator screw does not rotate causes the anterior actuator to move independently of the posterior actuator.

In at least one embodiment, the implant may include one or more bearings. The bearings may be configured to connect one or both of the end plates to the actuator assembly and allow the actuator screw to rotate regardless of end plate angulation. For example, the posterior end of the actuator screw may include a ball which is supported in a spherical bearing supported by the first and second end plates. In an alternative arrangement, the implant may be provided without bearings present, such that the end plates would be free to pivot or translate without restriction.

In at least one embodiment, the disclosure provides a method of fusing adjacent vertebral bodies including inserting an implant defining a longitudinal axis extending between distal and proximal ends between bones of the joint, the implant includes a first end plate extending between an anterior end and a posterior end. The first end plate has a bone engaging surface, at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface. A second end plate extends between an anterior end and a posterior end. The second end plate has a bone engaging surface, at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface. A posterior actuator is positioned between the first and second end plates and has a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface. A pivot member is pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a pivot member is pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface. An anterior actuator is positioned between the first and second end plates and has a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface. A pivot member is pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a pivot member is pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface. An actuator assembly extends between the posterior actuator and the anterior actuator and is configured to selectively move the posterior actuator and the anterior actuator simultaneously, move posterior actuator independently of the anterior actuator, or move the anterior actuator independently of the posterior actuator. The method further includes actuating the actuator assembly after the implant is inserted to move the first and second end plates relative to one another to increase or decrease the lordotic angle or to move the first and second endplates farther apart to separate bones of the joint.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the present disclosure, are incorporated in and constitute a part of this specification, illustrate aspects of the present disclosure and together with the detailed description serve to explain the principles of the present disclosure. No attempt is made to show structural details of the present disclosure in more detail than may be necessary for a fundamental understanding of the present disclosure and the various ways in which it may be practiced. In the drawings:

FIG. **1** is an exploded perspective view of an implant in accordance with an embodiment of the disclosure;

FIG. **2** is a perspective view of the implant of FIG. **1** in a compressed or reduced height configuration, together with three mounted bone screws;

FIG. **3** is a side elevation view of the implant as shown in FIG. **2**;

FIG. **4** is a perspective view of the implant of FIG. **1** in an expanded or increased height configuration, together with three mounted bone screws;

FIG. **5** is a side elevation view of the implant as shown in FIG. **4**;

FIG. **6** is a perspective view of the implant of FIG. **1** in a compressed or reduced height configuration, together with three mounted bone anchors;

FIG. **7** is a perspective view of the implant of FIG. **1** in an expanded or increased height configuration, together with three mounted bone anchors;

FIG. **8** is a perspective view of the implant of FIG. **1** in an expanded anterior or increased lordotic angle configuration;

FIG. **9** is a side elevation view of the implant as shown in FIG. **8**;

FIG. **10** is a perspective view of the implant of FIG. **1** in an expanded superior or decreased lordotic angle configuration;

FIG. **11** is a side elevation view of the implant as shown in FIG. **10**;

FIG. **12** is a cross-sectional view along the line **12-12** in FIG. **8**;

FIG. **13** is a cross-sectional view along the line **12-12** in FIG. **9**; and

FIGS. **14-16** are expanded perspective views of a portion of an alternative actuator showing the sequential mounting of an alternative pivot member relative thereto.

DETAILED DESCRIPTION

The aspects of the present disclosure and the various features and advantageous details thereof are explained more fully with reference to the non-limiting aspects and examples that are described and/or illustrated in the accompanying drawings and detailed in the following description. It should be noted that the features illustrated in the drawings are not necessarily drawn to scale, and features of one aspect may be employed with other aspects as the skilled artisan would recognize, even if not explicitly stated herein. Descriptions of well-known components and processing techniques may be omitted so as to not unnecessarily obscure the aspects of the present disclosure. The examples used herein are intended merely to facilitate an understanding of ways in which the present disclosure may be practiced and to further enable those of skill in the art to practice the aspects of the present disclosure. Accordingly, the examples and aspects herein should not be construed as limiting the scope of the present disclosure, which is defined solely by the appended claims and applicable law. Moreover, it is noted that like reference numerals represent similar parts throughout the several views of the drawings.

The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms "including" and "having," as used herein, are defined as comprising (i.e., open language).

Implants of the disclosure allow for insertion into the intervertebral disc space at a minimized height and then expansion axially to restore height loss in the disc space. Implants of the disclosure allow continuous expansion and retraction within a range of expansion as well as achieving optimal height restoration. Implants of the disclosure may also change in lordotic angulation independently from its expansion. Implants of the disclosure may be utilized to minimize impaction during insertion, visual obstruction, and imperfect matching with a patient's lordosis due to discrete increments in lordotic angulation. Additionally, implants of the disclosure may also be collapsed and repositioned, as therapeutically indicated for the patient.

Referring to FIGS. **1-5** and **7-13**, an implant **100** in accordance with an embodiment of the disclosure will be described. The implant **100** is operative, when positioned between adjacent bones of a joint, such as for example vertebrae (not shown), to stabilize a joint formed by adjacent vertebrae. The implant **100** is illustrated in an anterior interbody spacer configuration but it could also be used in other approaches, for example, such as direct lateral where coronal deformity is encountered.

With reference to FIGS. **1-3**, the implant **100** generally includes upper and lower endplates **110**, **130**, anterior and posterior actuators **150**, **170**, actuator pivot members **190**, **200**, an actuator screw **210**, an actuator nut **220**, a spherical bearing **240** and a thrust washer **230**. In addition, the implant may include a plurality of blocking screws **124** on the endplates **110**, **130** to prevent migration of the fixation screws or anchors.

The upper end plate **110** includes a posterior rail **111** and an anterior rail **113** extending between opposed side rails **112**, **114**. The rails **111-114** extend about a through passage **115** into a graft chamber **128** within the implant. The passage **115** allows graft material or other therapeutically beneficial material to packed into or grow into the graft chamber **128**. The upper end plate **110** defines a posterior guide ramp **116** along each side rail **112**, **114** and an anterior guide ramp **118** along each side rail **112**, **114**. Each posterior guide ramp **116** defines a groove **117** configured to receive a portion of a respective pivot member **190** and each anterior guide ramp **118** defines a groove **117** configured to receive a portion of a respective pivot member **190**. As will be described hereinafter, the pivot members **190** are pivotally connected to respective actuators **150**, **170** and slide along the respective ramp **116**, **118** as the plates **110**, **130** expand or contract.

The anterior rail **113** defines at least one bone screw/anchor through hole **121**, with one such hole **121** shown in the illustrated embodiment. A blocking screw hole **122** is positioned next to the through hole **121** and is configured to receive a blocking screw **124** which may be utilized to maintain the bone screw **250** or bone anchor **260** in the through hole **121**. It will be appreciated that the bone screw **250** and bone anchor **260** may be used interchangeably in the respective hole **121** and may also be substituted with any other suitable fasteners. The anterior rail **113** also defines a first hemispherical portion **125** of a driver opening **143** as shown in FIG. **2**. The posterior rail **111** defines a first hemispherical portion **127** of a seat for the spherical bearing **240**, as will be described hereinafter. A receiving slot **126** extends next to the hemispherical portion **127** and is configured to receive a flange **246** of one of the bearing members **241** that defines a portion of the spherical bearing **240**.

The lower end plate **130** includes a posterior rail **131** and an anterior rail **133** extending between opposed side rails **132**, **134**. The rails **131-134** extend about a through passage **135** into the graft chamber **128** within the implant. The passage **135** again allows graft material or other therapeutically beneficial material to packed into or grow into the graft chamber **128**. The lower end plate **130** defines a posterior guide ramp **136** along each side rail **132**, **134** and an anterior guide ramp **138** along each side rail **132**, **134**. The guide ramps **136** and **138** are laterally inward of the ramps **116**, **118** such that the ramps **116**, **118** may overlap the ramps **136**, **138**. Each posterior guide ramp **136** defines a groove **137** configured to receive a portion of a respective pivot member **190** and each anterior guide ramp **138** defines a groove **137** configured to receive a portion of a respective pivot member **200**. As will be described hereinafter, the pivot members **190**, **200** are pivotally connected to respective actuators **150**, **170** and slide along the respective ramp **136**, **138** as the plates **110**, **130** expand or contract.

The anterior rail **133** defines at least one bone screw/anchor through hole **141**, with two such holes **141** shown in the illustrated embodiment. A blocking screw hole **142** is positioned next to each through hole **141** and is configured to receive a blocking screw **124** which may be utilized to maintain the bone screw **250** or bone anchor **260** in the through hole **141**. It will be appreciated that the bone screw **250** and bone anchor **260** may be used interchangeably in the respective holes **141** and may also be substituted with any other suitable fasteners. The anterior rail **133** also defines the second hemispherical portion **145** of the driver opening **143** as shown in FIG. **2**. The posterior rail **131** defines the second hemispherical portion **147** of the seat for the spherical bearing **240**. A receiving slot **146** extends next to the hemispherical portion **127** and is configured to receive a flange **246** of the other of the bearing members **241** that defines another portion of the spherical bearing **240**.

Although anterior rails **113**, **133** are shown with through holes **121**, **141** configured to receive respective fasteners, it will be appreciated by one skilled in the art that the bore holes or through holes **121**, **141** may be present in any suitable number and configuration for fixation. In the alternative, the bore holes or through holes **121**, **141** may be omitted to provide a standalone device.

While not shown, one or both of the end plates **110**, **130** can be provided with teeth or other projections which can penetrate body tissue to reduce a likelihood of migration of implant **100** after implantation. Additionally, one or both of the end plates **110**, **130** may be coated with or impregnated with therapeutic agents, including bone growth, healing, antimicrobial, or drug materials, which may be released at a therapeutic rate, using methods known to those skilled in the art. Additionally, while FIGS. **2-5** show bone screws **260** extending through the through holes **121**, **141** for securing of the implant **100**, the disclosure is not limited to such. For example, FIGS. **6** and **7** illustrate bone anchors **260** extending through the through holes **121**, **141**. Other anchoring elements may also be utilized. In each case, the through holes **121**, **141** may have a concave opening such that the screws **250** or anchors **260** may be inserted into body tissue at an optimal angle with respect to implant **100**, whereby optimal purchase may be obtained, or certain body tissue may be avoided.

Implant **100** has a collapsed state or height, illustrated in FIGS. **2** and **3**, and an expanded state or height, illustrated in FIGS. **4** and **5**. Implants **100** of the disclosure may be inset into the intervertebral disc space at a collapsed height, and then expand axially (superior/inferior) to restore height loss in the disc space. The implant provides distraction as well as achieves optimal height restoration. When inserted in a collapsed state, implants **100** reduce impaction to tissue in the joint space during insertion, and form the least visually blocking or obstructing profile. Additionally, the lordotic angle of implant **100** may be adjusted to have an increased lordotic angle, illustrated in FIGS. **8** and **9**, or a decreased lordotic angle, illustrated in FIGS. **10** and **11**.

The anterior and posterior actuators **150**, **170** are positioned between the plates **110**, **130** and are moveable relative to the plates **110**, **130** to control the separation between the plates **110**, **130**. The anterior actuator **150** is positioned between the plates **110**, **130** proximate the anterior rails **111**, **131**. The anterior actuator **150** has a laterally extending body **152** with a central through passage **154** with internal threads **155** configured to threadably engage the actuator screw **210**, as will be described hereinafter. An upper plate guiding ramp **156** is defined at each end of the body **152** and is configured to align with a respective anterior ramp **116** of the upper plate **110**. Each of the upper plate guiding ramps **156** extends at the same incline angle as the opposing anterior ramp **116**. Similarly, a lower plate guiding ramp **157** is defined inward of each end of the body **152** and is configured to align with a respective anterior ramp **136** of the lower plate **130**. Each of the lower plate guiding ramps **157** extends at the same incline angle as the opposing anterior ramp **136**. The body **152** defines pivot pin holes **158**, **159** next to the guiding ramps **156**, **157**, respectively, for pivotal mounting of the pivot members **190**.

The posterior actuator **170** is positioned between the plates **110**, **130** proximate the posterior rails **113**, **133**. The anterior actuator **170** has a laterally extending body **172** with a central non-threaded through passage **174** configured to receive the actuator nut **220**. A series of fingers **180** extend from the posterior side of the body **172** about the through passage **174** and are configured to engage and retain the actuator nut **220**, as will be described hereinafter. An upper plate guiding ramp **176** is defined at each end of the body **172** and is configured to align with a respective posterior ramp **118** of the upper plate **110**. Each of the upper plate guiding ramps **176** extends at the same incline angle as the opposing superior ramp **118**. Similarly, a lower plate guiding ramp **177** is defined inward of each end of the body **172** and is configured to align with a respective superior ramp **138** of the lower plate **130**. Each of the lower plate guiding ramps **177** extends at the same incline angle as the opposing superior ramp **138**. The body **172** defines pivot pin holes **178**, **179** next to the guiding ramps **176**, **177**, respectively, for pivotal mounting of the pivot members **190**, **200**.

Referring to FIG. **1**, each of the pivot members **190** includes a guide surface **192** configured to engage and slide along a respective ramp **116**, **118**, **136**. A groove engaging flange **194** extends from each guide surface **192** and is configured to engage within the respective ramp groove **117**, **119**, **137** to prevent separation from the respective ramp **116**, **118**, **136**. The opposite side of each guide surface **192** defines a pivot slot **196** configured to align with respective pivot pin holes **158**, **159**, **178** such that a pivot pin (not shown) pivotally connects each pivot member **190** to a respective actuator **150**, **170**. The pivot members **200** are similar to the pivot members **190** and includes a guide surface **202** configured to engage and slide along a respective ramp **138**. A groove engaging flange **204** extends from each guide surface **202**, more centrally compared to the pivot member **190**, and is configured to engage within the respective ramp groove **139** to prevent separation from the respective ramp **138**. The opposite side of each guide surface **202** defines a pivot slot **206** configured to align with respective pivot pin holes **179** such that a pivot pin (not shown) pivotally connects each pivot member **200** to a respective actuator **170**.

Referring to FIGS. **14-16**, an alternative method of pivotally connecting the pivot members to the actuators will be described. While the figures show a posterior actuator **150'**, a similar construction may be provided for the anterior actuator. In the present embodiment, each of the ramps **156**, **157** defines a pivot slot **160** with a portion **162** that extends laterally under a portion of the actuator body **152'**. Instead of a pivot pin slot, each pivot member **190'** has a rounded underside member **198** with an extending portion **197**. The rounded underside member **198** fits into the pivot slot **160** with the extending portion **197** fitting into the portion **162** that extends laterally under a portion of the actuator body **152'**. When fully placed as illustrated in FIG. **16**, the pivot member **190'** is retained in the actuator and is pivotal thereto.

The pivot members **190**, **200** are pivotally connected to and thereby move with the respective actuator **150**, **170** while also being engaged with the grooves **117**, **119**, **137**, **139** in the upper and lower end plates **110**, **130**. As such, as the actuators **150**, **170** are moved anteriorly or posteriorly, the pivot members **190**, **200** slide along the ramps **116**, **118**, **136**, **138** causing the end plates **110**, **130** to move toward or away from one another. The pivoting nature of the pivot members **190**, **200** allows the angle between the plates **110**, **130** to be changed while maintaining the sliding relationship.

Movement of the actuators **150**, **170** and the corresponding movement of the end plates **110**, **130** will now be described. FIGS. **2** and **3** illustrate the end plates **110**, **130** in the collapsed state and the actuators **150**, **170** are both generally centrally located. To move the end plates **110**, **130** to the expanded state, the anterior actuator **150** moves anteriorly and the posterior actuator **170** moves posteriorly, as shown in FIGS. **4** and **5**. As the actuators **150**, **170** move, the pivot members **190**, **200** slide along the respective ramps **116**, **118**, **136**, **138**. In such expanding actuation, the actuators **150**, **170** are moved at the same rate and therefore the end plates **110**, **130** maintain the given angle between them and the pivot members **190**, **200** generally do not pivot. If it is desired to increase the lordotic angle between the plates **110**, **130**, the anterior actuator **170** is moved anteriorly while the posterior actuator **150** remains stationary, as illustrated in FIGS. **8** and **9**. As the anterior actuator **170** moves, the pivot members **190**, **200** slide along the respective ramps **118**, **138**. Additionally, because the angle between the end plates **110**, **130** changes, each of the pivot members **190**, **200** pivots relative to its respective actuator **150**, **170**. Conversely, if it is desired to decrease the lordotic angle between the plates **110**, **130**, the posterior actuator **150** is moved posteriorly while the anterior actuator **170** remains stationary, as illustrated in FIGS. **10** and **11**. As the posterior actuator **150** moves, the pivot members **190** slide along the respective ramps **116**, **136**. Again, because the angle between the end plates **110**, **130** changes, each of the pivot members **190**, **200** pivots relative to its respective actuator **150**, **170**.

To facilitate movement of the actuators **150**, **170**, an actuator assembly extends between the actuators **150**, **170**. Referring to FIGS. **1**, **12** and **13**, in the present embodiment, the actuator assembly includes an actuator screw **210**, an actuator nut **220**, and a spherical bearing **240**. The actuator screw **210** includes a shaft extending between a posterior end **211** and an anterior end **213**. The posterior end **211** of the screw **210** has a ball **214** while the anterior end **213** includes a driver receiver **216**. The actuator screw **210** has a first set of threads **217** on the anterior end and a second set of threads **218** on the posterior end with a flange **215** in between. The first and second sets of threads **217**, **218** are oppositely handed, i.e. one set is right handed while the other set is left handed. The posterior end **211** of the actuator screw **210** extends through the central through passage **154** of the posterior actuator **150** with the with threads **217** engaged with the internal threads **155**.

The ball **214** of the actuator screw **210** extends beyond the posterior actuator **150** and is retained in the spherical bearing **240**. In the present embodiment, the spherical bearing **240** is defined by opposed bearing members **241**. With reference to FIG. **1**, each bearing member **241** has a generally hemispherical bearing surface **242**. An arm **244** extends between the bearing surface **242** and a mounting flange **246**. Each mounting flange **246** is configured to be received in a respective receiving slot **126**, **146** of the upper end plate **110** or the lower end plate **130**. With the ball **214** retained between the bearing surfaces **242** and the flanges **246** engaged with the respective end plates **110**, **130**, the actuator screw **210** is axially fixed relative to the end plates **110**, **130** but is free to pivot relative thereto. As such, as the posterior actuator **150** moves along the thread set **217** of the actuator screw **210**, the posterior actuator **150** moves relative to the end plates **110**, **130**.

The actuator nut **220** has a body **222** extending between a posterior end **221** and an anterior end **223**. A through passage **227** extends through the body **222** from the anterior end **223** to the posterior end **221**. A portion of through passage **227** defines internal threads **228** which are configured to threadably engage the second thread set **218** of the actuator screw **210**. A shoulder **229** is defined within the through passage **227** to define a stop for the actuator screw **210**. The anterior end **223** of the actuator nut **220** defines a driver engagement **226** about the through passage **227**, which in the illustrated embodiment is a series of notches and teeth.

The anterior end **223** of the body **222** of the actuator nut **220** is configured to be received into the non-threaded through passage **174** of the anterior actuator **170**. A radial flange **224** extending from the body **222** limits the extent the actuator nut **220** moves into the non-threaded through passage **174**. A thrust washer **230** may be positioned between the flange **224** and the anterior actuator **170**. A groove **225** is defined in the actuator nut body **222** posteriorly of the flange **224**. The fingers **180** extending from the anterior actuator **170** are configured to engage the groove **225** such that the actuator nut **220** is connected to the anterior actuator **170**.

The actuator assembly provides three modes of operation. In the first mode of operation, the actuator screw **210** is turned via the driver receiver **216** while the actuator nut **220** is not turned. Engagement of the internal threads **155** of posterior actuator **150** with the first set of threads **217** of the turning actuator screw **210** causes the posterior actuator **150** to move, for example posteriorly. At the same time, since the opposite handed threads **218** of the turning actuator screw **210** are engaging the internal threads **218** of the non-turning actuator nut **220**, the actuator nut **220**, and thereby the anterior actuator **170**, are caused to move in the opposite direction, in this example, anteriorly. This results in both actuators **150**, **170** moving toward the ends of the end plates **110**, **130** and gives linear expansion with both endplates **110**, **130** expanding the same distance (FIGS. **4** and **5**). Turning the actuator screw **210** in the opposite direction would move the end plates **110**, **130** toward one another.

In the second mode of operation, the actuator screw **210** is not turned while the actuator nut **220** is turned via the driver engagement **226**. Since the actuator screw **210** is not turning, the posterior actuator **150** does not move. However, as the actuator nut **220** turns relative to the thread set **218** of the stationary actuator screw **210**, the actuator nut **220**, and thereby the anterior actuator **170**, move alone which expands the anterior end of each endplate only and results in an increase in lordotic angle. (FIGS. **8** and **9**). Turning the actuator nut **220** in the opposite direction would move the anterior ends of end plates **110**, **130** toward one another.

In the third mode of operation, the actuator screw **210** is turned via the driver receiver **216** while the actuator nut **220** is also turned via the driver engagement **226**. Since the actuator screw **210** and the actuator nut **220** are turning at the same rate, there is no relative movement between the actuator nut **220** and the actuator screw **210**. As such, the anterior actuator **170** does not move. However, the turning actuator screw **210** causes the posterior actuator **150** to move alone which expands the posterior end of each endplate only and results in a reduction in lordosis. (FIGS. **10** and **11**). Turning the actuator screw and actuator nut **220** simultaneously in the opposite direction would move the posterior ends of end plates **110**, **130** toward one another.

Devices of the disclosure provide for adjacent vertebrae to be supported during flexion/extension, lateral bending, and axial rotation. In one embodiment, implant **100** is indicated for spinal arthroplasty in treating skeletally mature patients with degenerative disc disease, primary or recurrent disc herniation, spinal stenosis, or spondylosis in the lumbosacral spine (LI-SI). Degenerative disc disease is advantageously defined as discogenic back pain with degeneration of the disc confirmed by patient history and radiographic studies, with or without leg (radicular) pain. Patients may be advantageously treated, for example, who may have spondylolisthesis up to grade 1 at the involved level. The surgery position implant **100** may be performed through an anterior, anterolateral, posterolateral, and/or lateral approach. Various implant methods are disclosed in US 2014/0277489, the contents of which are incorporated herein by reference in its entirety for all purposes. During implantation, the driver receiver **216** and driver engagement **226** may be engaged by separate tools or an integrated tool to actuate the actuator assembly.

While the present disclosure has been described in terms of exemplary aspects, those skilled in the art will recognize that the present disclosure can be practiced with modifications in the spirit and scope of the appended claims. These examples given above are merely illustrative and are not meant to be an exhaustive list of all possible designs, aspects, applications or modifications of the present disclosure.

What is claimed is:

1. An implant for therapeutically separating bones of a joint, the implant comprising:

a first end plate extending between an anterior end and a posterior end, the first end plate having a bone engaging surface, and having at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface;

a second end plate extending between an anterior end and a posterior end, the second end plate having a bone engaging surface, and having at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface;

a posterior actuator positioned between the first and second end plates, the posterior actuator having a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface;

a first pivot member pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a second pivot member pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface;

an anterior actuator positioned between the first and second end plates, the anterior actuator having a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface;

a third pivot member pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a fourth pivot member pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface; and

an actuator assembly extending between the posterior actuator and the anterior actuator, the actuator assembly configured to selectively move the posterior actuator and the anterior actuator simultaneously, move posterior actuator independently of the anterior actuator, or move the anterior actuator independently of the posterior actuator.

2. The implant of claim **1**, wherein at least one of the first and second end plates defines a through passage into a graft chamber between the first and second end plates.

3. The implant of claim **1**, wherein at least one of the first and second endplates includes at least one through hole through which a fastener may pass to secure the implant to bone of the joint.

4. The implant of claim **3**, wherein the fastener is a bone screw or a bone anchor.

5. The implant of claim **1**, further including a blocking mechanism configured to prevent backing out of a fastener passed through at least one of the first and second endplates and into body tissue.

6. The implant of claim **1**, wherein the first end plate has two anterior ramped surfaces and two posterior ramped surfaces on the side opposite the bone engaging surface; and

the second end plate has two anterior ramped surfaces and two posterior ramped surfaces on the side opposite the bone engaging surface.

7. The implant of claim **1**, wherein each of the anterior and posterior ramped surfaces has a groove extending therealong and each pivot member has a groove engaging flange which engages a respective groove and prevents separation of the pivot member relative to the respective ramped surface.

8. The implant of claim **1**, wherein the actuator assembly includes:

an actuator screw extending between a posterior end and an anterior end with a first external thread set proximate the posterior end and a second external thread set proximate the anterior end, the first and second external thread sets being oppositely handed, wherein the posterior end of the actuator screw extends through and threadably engages a through passage in the posterior actuator; and

and an actuator nut extending between a posterior end and an anterior end with a through passage extending from the posterior end to the anterior end and defining an internal thread within the through passage, the internal thread threadably engaged with the second set of external threads, wherein the actuator nut extends through anterior actuator such that the actuator nut is axially fixed relative to the anterior actuator but rotatable relative thereto.

9. The implant of claim **8**, wherein the proximal end of the actuator screw is fixed axially relative to the first and second end plates.

10. The implant of claim **9**, wherein the posterior end of the actuator screw includes a ball which is supported in a spherical bearing supported by the first and second end plates.

11. The implant of claim **8**, wherein the anterior end of the actuator screw defines a driver receiver.

12. The implant of claim **8**, wherein the actuator nut includes a body with a radial flange extending outwardly between anterior end of the body and a posterior end of the body, wherein the anterior end of the body is received in a through passage defined in the anterior actuator.

13. The implant of claim **12**, wherein the anterior end of the body defines a driver engagement about the actuator nut through passage.

14. The implant of claim **12**, wherein a thrust washer is positioned between the radial flange and the anterior actuator.

15. The implant of claim **12**, wherein fingers extend from the anterior actuator and engage a groove in the actuator nut body posteriorly of the flange.

16. The implant of claim **8**, wherein the actuator assembly is operable in one of three modes including a first mode wherein the actuator screw is rotated and the actuator nut is not rotated such that the posterior and anterior ends of both endplates move away from each other the same distance; a second mode wherein the actuator screw is not rotated while the actuator nut is rotated such that the anterior actuator moves alone which expands the anterior end of each end plate only and results in an increase in lordotic angle; and a third mode wherein the actuator nut and actuator screw are rotated simultaneously which moves the posterior actuator only resulting in expansion of the posterior ends of the endplates and thereby a reduction in lordosis.

17. An implant comprising:

a first end plate extending between an anterior end and a posterior end, the first end plate defining at least one anterior ramped surface and at least one posterior ramped surface;

a second end plate extending between an anterior end and a posterior end, the second end plate defining at least one anterior ramped surface and at least one posterior ramped surface;

a posterior actuator positioned between the first and second end plates, the posterior actuator having a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface;

a first pivot member pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a second pivot member pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface;

an anterior actuator positioned between the first and second end plates, the anterior actuator having a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface;

a third pivot member pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a fourth pivot member pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface; and

an actuator assembly extending between the posterior actuator and the anterior actuator, the actuator assembly including:

an actuator screw extending between a posterior end and an anterior end with a first external thread set proximate the posterior end and a second external thread set proximate the anterior end, the first and second external thread sets being oppositely handed, wherein the posterior end of the actuator screw extends through and threadably engages a through passage in the posterior actuator; and

an actuator nut extending between a posterior end and an anterior end with a through passage extending from the posterior end to the anterior end and defining an internal thread within the through passage, the internal thread threadably engaged with the second set of external threads, wherein the actuator nut extends through the anterior actuator such that the actuator nut is axially fixed relative to the anterior actuator but rotatable relative thereto;

wherein rotation of the actuator screw while the actuator nut does not rotate causes the posterior actuator and the anterior actuator to move simultaneously, rotation of the actuator screw and the actuator nut together causes the posterior actuator to move independently of the anterior actuator, and rotation of the actuator nut while the actuator screw does not rotate causes the anterior actuator to move independently of the posterior actuator.

18. The implant of claim **17**, wherein the actuator assembly is operable in one of three modes including a first mode wherein the actuator screw is rotated and the actuator nut is not rotated such that the posterior and anterior ends of both endplates move away from each other the same distance; a second mode wherein the actuator screw is not rotated while the actuator nut is rotated such that the anterior actuator moves alone which expands the anterior end of each end plate only and results in an increase in lordotic angle; and a third mode wherein the actuator nut and actuator screw are rotated simultaneously which moves the posterior actuator only resulting in expansion of the posterior ends of the endplates and thereby a reduction in lordosis.

19. A method of fusing adjacent vertebral bodies, comprising:

inserting an implant defining a longitudinal axis extending between distal and proximal ends between bones of the joint, the implant comprising:

a first end plate extending between an anterior end and a posterior end, the first end plate having a bone engaging surface, and having at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface;

a second end plate extending between an anterior end and a posterior end, the second end plate having a bone engaging surface, and having at least one anterior ramped surface and at least one posterior ramped surface on a side opposite the bone engaging surface;

a posterior actuator positioned between the first and second end plates, the posterior actuator having a corresponding number of first guiding ramp surfaces configured to be positioned opposite the at least one first end plate posterior ramped surface and a corresponding number of second guiding ramp surfaces configured to be positioned opposite the at least one second end plate posterior ramped surface;

a first pivot member pivotally connected to each first guiding ramp surface and in sliding engagement with the respective at least one first plate posterior ramped surface and a second pivot member pivotally connected to each second guiding ramped surface and in sliding engagement with the respective at least one first plate posterior ramped surface;

an anterior actuator positioned between the first and second end plates, the anterior actuator having a corresponding number of third guiding ramp surfaces configured to be positioned opposite the at least one first end plate anterior ramped surface and a corresponding number of fourth guiding ramp surfaces configured to be positioned opposite the at least one second end plate anterior ramped surface;

a third pivot member pivotally connected to each third guiding ramp surface and in sliding engagement with the respective at least one first plate anterior ramped surface and a fourth pivot member pivotally connected to each fourth guiding ramped surface and in sliding engagement with the respective at least one first plate anterior ramped surface; and

an actuator assembly extending between the posterior actuator and the anterior actuator, the actuator assembly configured to selectively move the posterior actuator and the anterior actuator simultaneously, move posterior actuator independently of the anterior actuator, or move the anterior actuator independently of the posterior actuator; and

actuating the actuator assembly after the implant is inserted to move the first and second end plates relative to one another to increase or decrease the lordotic angle or to move the first and second endplates farther apart to separate bones of the joint.

20. The method of claim **19** wherein actuation of the actuator assembly is in one of three modes including a first mode wherein an actuator screw is rotated and the actuator nut is not rotated such that the posterior and anterior ends of both endplates move away from each other the same distance; a second mode wherein the actuator screw is not rotated while the actuator nut is rotated such that the anterior actuator moves alone which expands the anterior end of each end plate only and results in an increase in lordotic angle; and a third mode wherein the actuator nut and actuator screw are rotated simultaneously which moves the posterior actuator only resulting in expansion of the posterior ends of the endplates and thereby a reduction in lordosis.

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